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OF CEYLON

THE TEA RESEARCH INSTITUTE,
St. Coombs, Talawakele,
Ceylon.

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EDITORIAL COMMENT

This number of the *Tea Quarterly* is small: size has been sacrificed to promptness of publication. It is not possible for the Institute at present to produce enough properly finished research results, pithily described, to fill every issue of a full-sized *Quarterly*. In this issue there are introductory articles on mite pests of tea and on eelworms. As further work on mites is published, Mr Cranham's review article will serve as a background for it.

Eelworms

Dr Hutchinson's article on eelworms, which he prefers to call by the more-embracing name of nematodes, defines certain terms which have become important in selecting clones for vegetative propagation. His clonal testing programme, his survey, and the large number of soil samples being sent in by estates, are putting a strain on the eelworm assessment accommodation and the nematology staff. For this reason, estates are now asked not to send in more than three soil samples at a time for eelworm assessment, unless special arrangements have been made with the Nematologist.

The Institute's Recommendations

It is not uncommon for planters to do things that are not recommended by the Institute. In some cases, this is simply because the Institute must be sure before it can recommend; it takes time to make sure and the Institute's recommendation sometimes eventually confirms what has been to some extent already practised. In other cases, the Institute is aware of dangers or weaknesses in practices that are beginning to spread. For example, the Institute has failed to discover any advantage in using stickers in blister-blight spraying; but because some planters do use a sticker, further work is being done by Dr Mulder.

Shot-hole Borer

Again, Dr Judenko has shown that considerable reductions can be produced in shot-hole-borer populations by spraying the lower parts of tea in plucking with 1½ lb. of dieldrin in 100 gallons of water per acre; but he is still not recommending this. Some planters are using dieldrin (though mostly on freshly pruned frames), but other investigations, which Dr Judenko lists, are required before the Institute can follow a firm line. It is already known that most such dieldrin spraying operations are followed by Tea Tortrix outbreaks and, incidentally, many of the outbreaks of Tea Tortrix follow such dieldrin spraying. Enquiries are being made about the present importance of such outbreaks, compared with the importance of shot-hole-borer attacks themselves. It is a reasonable inference, however, that if dieldrin spraying were to become the universal practice in shot-hole-borer country, the importance of Tea Tortrix would increase as the migration distance imposed on the tortrix parasite (*Macrocentrus homonae*) increased.

Miscellaneous

As we go to press with this issue of the *Tea Quarterly*, the previous issue is being completed by the printers; that is to say, it is too early for any response to the suggestion made that planters should contribute more material to the *Tea Quarterly*. The suggestion stands.

General news regarding the Institute is that advertisements have appeared for two Heads of Divisions, the Biochemist and the Plant Breeder, and applications are coming in. The Biochemistry Division is revived as a separate Division and the Plant Breeding Division is a new one.

THE MITE PESTS OF TEA: A REVIEW

J. E. Cranham

Mites are common pests of a wide variety of crops in many countries, and experience elsewhere is useful in considering mites on tea in Ceylon. The present article is addressed to tea planters and relates certain aspects of local mite problems to overseas experience. We are often asked whether mites are insects, whether the species on Ceylon tea are peculiar to Ceylon, whether chemical sprays that are effective elsewhere can be used on tea, why mite problems on tea have been more serious in recent years, and similar questions. It is these issues which will concern us here.

Mites are not insects; together with ticks they form the order Acari, of the class Arachnida (including spiders). This group is no more closely related to insects than, say, birds are to mammals. There is practical significance in this point, not least in the differing response to insecticides, many of which are not only valueless against mites but sometimes actually lead to increased populations.

The study of mites is less advanced than that of insects. Because of their small size, they are seldom conspicuous, although there is a vast number of species and they are found in almost every habitat available to animal life—in the soil, in both fresh and salt waters, in stored food and other stored products, and parasitic both on other animals and on plants. Of the phytophagous (plant-feeding) mites, there are four families most commonly concerned, all of which are represented by species on tea.

The **Tetranychidae** or spider mite family, of which hundreds of species have been recorded on plants, several of major economic importance as pests, contains the Tea Red Spider Mite (*Oligonychus coffeae* Nietner). Some other members of the group are the Fruit Tree Red Spider Mite (*Panonychus ulmi* Koch), the Glasshouse Red Spider Mite (*Tetranychus telarius* L.) and the Citrus Red Mite (*Panonychus citri* McG.). *Oligonychus coffeae* occurs on tea in most, if not all, tea areas of S.E. Asia; in N.E. India it is a more serious pest than it is in Ceylon. This species has also been recorded from the Transvaal, Florida, and Queensland, Australia (Pritchard and Baker, 1955). It has a fairly wide range of host plants (Das, 1959) but in Ceylon high numbers are common only on tea, *Grevillea robusta* and *Albizzia moluccana.* The last host plant is synonymous with *Albizzia falcata,* considered by Holland (1931) to be the correct name.

The family **Tenuipalpidae,** or False Spider Mites, includes the Scarlet Mites on tea (*Brevipalpus californicus* Banks and other *Brevipalpus* species). This family is not of such great economic importance as the allied Tetranychidae, but several species are pests of fruit crops and ornamental plants, chiefly in Mediterranean and sub-tropical climates. *Brevipalpus californicus* has a very wide geographical distribution and 43 host plants are listed by Pritchard and Baker (1958) including citrus, tea, and ornamental plants.

The family **Tarsonemidae,** which is very different from the other two mentioned above, includes the Yellow Mite (*Hemitarsonemus latus* Banks). This species is also recorded on citrus, tomato, vines, etc. in the U.S.A., *Cinchona* and *Hevea* species in Indonesia (Ewing, 1939), glasshouse ornamentals in the U.K. (Fox-Wilson, 1950), cotton in the Belgian Congo (Vrydagh, 1942), and potatoes in Queensland, Australia (Hooper, 1956). This species is therefore very widely known. Other tarsonemids are pests of bulbs, mushrooms, strawberries and oats.

The **Eriophyidae** include the Purple Mite (*Calacarus carinatus* Green); the family contains a great many species, variously called blister mites, rust mites, bud mites and gall mites, according to their habits. These are minute worm-like mites with only two pairs of legs. Various species are serious pests on fig, citrus, peach, pear and blackcurrents, in many countries. Purple Mite is recorded only on tea in India, Ceylon, S.E. Asia and Indonesia. Most eriophyid species are confined to one host plant.

The Damage Caused by Tea Mites

Scarlet Mite, Red Spider and Purple Mite feed mainly on the mature leaves and are not found on the 'flush,' except when it is hardened because of prolonged mite attacks on the bush or for other reasons. Yellow Mite, on the other hand, can breed in numbers only on the first two or three leaves of each flushing point. This species can and does cause immediate loss of crop, usually over relatively short periods (a few weeks), and high populations decrease as quickly as they build up.

Scarlet Mite and Red Spider do not normally injure the flush directly, but the damage caused by feeding on the mature leaves often causes defoliation. Evidence suggests that bushes stand very considerable defoliation without apparently affecting productivity (weight of crop taken) in the same pruning cycle. With severe Scarlet Mite attack, bushes suffer serious debilitation, and the new wood is spindly and unhealthy looking; it is often necessary to rest such bushes for some months before pruning or many fail to recover after pruning. The damage done by Scarlet Mite is thus chronic and insidious, and difficult to assess quantitatively; it is quite common, particularly up-country, and there is little doubt that, since the mites are not conspicuous, they are often overlooked as a cause of poor fields. This type of effect by leaf-feeding mites is quite typical; there are very few data on crop losses caused by any species of mites, even those which have been extensively investigated, *e.g.* Fruit Tree Red Spider.

Tea Red Spider has a greater capacity for rapid increase than Scarlet Mite; the mites are larger, more active and on the top surface of the leaves, so that heavy infestations are conspicuous and may cause acute damage. Moderate infestations may be largely overlooked and may cause the same long-term effect as Scarlet Mite. Red Spider is common in all mid-country districts around Kandy, in Uva (especially Haputale) and in some low-country districts. Damage due to Scarlet Mite, however, appears to be more common generally, and usually more serious.

Purple Mite attacks often occur in the first year after pruning in up-country tea and cause a purplish bronzing of the mature leaves, generally without defoliation. Purple Mite is, on the general evidence, the least injurious of the four mites on tea, and though often most apparent on weak and debilitated bushes, it is believed that the mites flourish most readily on weakly bushes, and not that they cause the weakness. It is quite possible, however, that attack by Purple Mite occurring early in the pruning cycle hardens the leaves sufficiently to render them more suitable to Scarlet Mite and Red Spider. In attacks of the latter two species, there are usually present abundant case skins of Purple Mites, which were active previously.

Certain fields have been noted in which all four species of mites are numerous, often with Green Bug (*Coccus viridis* Green) as well; such fields are then in very poor condition. The factors which lead to such a condition and the history of such fields require study. Mite attack is by no means confined to poor fields, however, although the weaker bushes present will usually suffer more.

Chemical Control

Sulphur in various forms is the oldest acaricide or miticide and is effective against all four species on tea. Unfortunately it taints the tea made from sprayed leaf and necessitates the discarding of at least three plucking rounds after spraying.

In many countries, mites have assumed much greater importance as economic pests in the last two or three decades. Of the factors which have caused this, the extensive use of the newer insecticides is unquestionably the most important, for they can reduce enormously the natural predators of plant-feeding mites.

It has been shown that DDT may induce increased mite populations by other effects additional to the destruction of predators; and this may apply to other insecticides. Davis (1952) showed that mites (*Tetranychus multisetis* McG.) on squash plants became very active shortly after contact with DDT, and scattered widely over the host plants, and that this dispersion resulted in an earlier mite build-up. Hueck (1953) has shown that DDT at low concentrations can induce an increased rate of egg-laying by the Fruit Tree Red Spider Mite, and has reviewed the literature on the subject.

Consequently, there has been extensive research to find new effective synthetic acaricides with desirable properties, *e.g.* toxicity to mite eggs (ovicidal) as well as to active stages, specific toxicity to mites, high persistence on foliage, and low mammalian toxicity. The older materials, such as sulphur, derris (rotenone) and 'white oils' (petroleum fractions) are no longer considered more than palliative (and sometimes useless) on fruit and other crops where they have been used extensively. It is outside the scope of this article to describe the large number of acaricides now available, several of which are remarkable pesticides having the desired properties. Unfortunately, mites (Red Spider Mites particularly) have demonstrated an aptitude for developing strains that are highly resistant to particular chemicals; and this has occurred on several crops where acaricides are used widely and repeatedly. Large quantities of synthetic acaricides are still used effectively by growers, but resistance has often developed with unusual rapidity and is a major problem.

From this brief outline of developments in acaricides, it will be seen that we might reasonably hope that some of these materials would be highly effective against tea mites and non-tainting to made tea. The occasional local use of such chemicals would, in theory, not be so liable to induce resistance as the more general and frequent use on, say, fruit crops. Tests at the T.R.I. have covered a range of materials, but so far nothing has proved more effective than sulphur. Certain materials are roughly as effective as sulphur against Scarlet Mite and Red Spider and do not taint after the normal seven day interval. These are chlorbenzilate, Kelthane, and Karathane. They are naturally more costly than elemental sulphur, so that to justify using them, the profit lost from the crop discarded when using sulphur must exceed the increased cost of the chemicals. This is often the case.

We do not know why certain synthetic acaricides which are much more effective than sulphur on, say, top fruit, are not so on tea. There are several possible reasons, and the result is probably due to a complex of them. Mite species, even closely related species, vary a great deal in their susceptibility to different materials and very little work has been done elsewhere on the control of our most important pest, Scarlet Mite. Initial spray residues may be less on tea, persistence (under heavy rainfall and bright sun) may be less, and spray coverage on mature tea is certainly poor by comparison with many crops. These and other factors have not been critically studied on tea; study might lead to the more efficient use of acaricides. Sulphur does not give as high a degree of control as is desirable. It is neither ovicidal nor very persistent and repeated applications are necessary. One virtue may be its volatility. Investigations by Lees (1923) and Goodwin and Martin (1929) showed that sulphur spray deposits at ordinary temperatures produce sufficient sulphur vapour to exert a fumigant acaricidal effect on Blackcurrant Big-Bud Mite (*Phytoptus ribis* Nal.). This is more marked in hot weather, and may be of particular importance on tea, where spray coverage is poor and the foliage canopy thick.

Effect of Copper Fungicides and Insecticides on Tea Mites

Planters often ask why in the last decade the mite problem on tea has become worse. The evidence that it is worse is not very convincing; though indeed it may be worse, we must bear in mind the fallibility of human memory, and the fact that the apparent numbers of such a pest depend very much on the interest of and recognition by the observer.

It is notable that all four species were recorded by E. Green between 1890 and 1900, Scarlet Mite and Yellow Mite as serious pests. Red Spider, which is more serious in N.E. India, was also serious there 60 years ago (Watt and Mann, 1903). In this respect therefore the mite problem on tea is unlike that on many crops where the increase in mites has unquestionably followed the use of synthetic insecticides, including DDT and some of the phosphorous insecticides. The use of these insecticides on Ceylon tea is so local and infrequent that it is inconceivable that they have had this sort of effect generally. In fact, there has not been a single case noted in Ceylon of DDT leading to an increase of mites or any other pest. This is certainly not to say that we can be sure that DDT is safe in this respect, but the evidence in Ceylon on tea does not suggest that it is very dangerous. By comparison, post-blossom sprays of DDT on top fruit in the U.K. almost invariably result in high numbers of Fruit Tree Red Spider.

The only chemicals that have been used on Ceylon tea very widely and frequently, are, of course, copper fungicides, mostly wettable powders of cuprous oxide and cuprous oxychloride. Many planters believe that these have caused a greater incidence of mites. This is certainly possible, but so far the T.R.I. has failed to establish conclusive evidence. Work was previously carried out by Loos who gave certain reasons (Loos, 1954) why he thought this effect was unlikely, namely (1) that copper sprays cover the flush and not the mature foliage on which the mites live and (2) that mites are most numerous when copper spraying ceases, in the dry season. Neither of these reasons seems valid to the writer. Yellow Mite lives only on the flush, and in point of fact copper sprays reach much of the top mature foliage bearing Scarlet Mite and Red Spider. Further, after the Yellow Mite is common in the intermonsoonal period (August-October) and just after the N. E. Monsoon (January-February) and not in the driest months. It is true that Scarlet Mite reaches peak numbers in April-May but the level of population then could easily depend on the numbers surviving the monsoon, which in turn could be affected by copper.

Recorded instances of copper causing such an increase in mites are rare, though they do exist, but copper is not now extensively used on many crops that suffer from mites. Thompson (1939) recorded that infestations of a rust mite (*Eriophyes oleivorus* Ashm.) developed on citrus in California with unusual consistency after copper sprays, although he was mainly concerned with the marked increase in a scale insect (*Lepidosaphes beckii* Newm.). Other pests were involved too, including Citrus Red Mite (*Panonychus citri* McG.). Holloway *et al* (1942) also recorded increase of *P. citri* McG. on California citrus after the use of sprays containing Bordeaux mixture and also sprays of zinc sulphate and soda ash.

It should be remembered that, in Ceylon, certain other cultural trends have developed over the same period, *e.g.* higher manuring and, up-country, lighter pruning. The latter quite probably affects the survival rate of Scarlet Mite at pruning time. There are various theories as to why copper sprays may result in increased mite populations, if indeed they do. It is not possible to investigate these until we can produce such an effect fairly consistently in experimental work.

Biological Control

Biological control is the control of pests by their naturally occurring predators or parasites, or by others introduced by man for the purpose. The insect and mite

predators of certain Red Spider and tarsonemid mites have been studied considerably. Very little information is recorded on predators of Scarlet Mites (*Brevipalpus* spp.). Investigation has in several instances, *e.g.* Fruit Tree Red Spider (Collyer, 1953) and Cyclamen Mite on strawberries (Huffaker & Kennett, 1953), shown that naturally occurring insect or mite predators will, in the absence of upset by chemical sprays, maintain the host species most of the time at a low level of population. Unfortunately, in commercial fruit growing, it is hardly ever possible to avoid the use of insecticides and fungicides for the control of other pests and diseases. In Nova Scotia, workers have devised spraying programmes that minimize the destruction of predators of Fruit Tree Red Spider (*see* Lord, 1949), but apple growing in this province is not highly commercialised, and the same sort of thing is not practicable for instance in British Columbia or the U.K. In California, Huffaker and Kennett (1956) have had some success in building up the numbers of mite predators of Cyclamen Mite on strawberries by artificial spread of prunings from older fields, carrying predators and prey species, to new fields of strawberries.

With a very few notable exceptions, however, it has not yet been possible to use the knowledge gained on mite predators to develop techniques of practical value. In this, the work is less advanced than that on the biological control of insect pests, which was for instance extraordinarily successful in Ceylon with the introduction of the *Macrocentrus* parasite of Tea Tortrix in 1935-1936 (Gadd, 1941). It can fairly be surmised, however, that the possibilities on a crop such as tea, on which there is no intensive spray programme, are considerably greater than, say, on top fruit.

Biology of Mites

A knowledge of the biology of a pest is usually vitally important in planning both preventative and curative measures. Mites quite often have resting or protected stages for surviving adverse climatic conditions; in temperate countries this usually means the winter, *e.g.* the winter eggs of Fruit Tree Red Spider on the bark of trees, the dormant adult phase of Glasshouse Red Spider, and the Big-Bud Mites (*Phytoptus ribis* Nal.) inside the dormant buds of blackcurrant bushes. A knowledge of the emergence periods and behaviour of these mites is very valuable.

In Ceylon, the adverse conditions for mites appear to occur during the monsoon, but as far as is known, none of the four species on tea has a special resting or protected stage with the function of surviving this period; smaller numbers of the normal stages can be found on the foliage, reproducing more slowly. Furthermore, all four species are very widely distributed in small numbers, and tea is a monoculture over large areas. The reproductive potential, even of the slower-breeding Scarlet Mite, is very great. They normally fail to achieve this potential because of various limiting factors, such as climatic factors, predators, and suitable host plants in the right condition.

Outbreaks occur when the complex of limiting factors becomes temporarily less stringent. Our knowledge of these limiting factors is very sketchy, particularly in regard to the condition of the host plant which stimulates or permits the rapid increase of mites. This involves both genetic factors (*e.g.* Scarlet Mite is generally more abundant on high-jat tea) and factors affecting the physiological condition of the plant, such as nutrient status, water balance and soil pH.

Planters often ask about the method of dispersal of tea mites. It is probable that it occurs largely by wind, by pluckers carrying the mites on clothing, and by animals, possibly including flying insects. There is no reason to think that dispersal is a very important factor contributing to outbreaks, for the mites are very widely distributed and their potential for increase is great. The main artificial break in the population occurs at pruning time. Unless pruning is completely clean (*i.e.*

all foliage and green twigs removed) and the area is also clean-weeded, mites survive in small numbers on the few leaves left and on various weeds. If completely clean pruning and weeding were carried out, then re-infestation from outside would necessarily be the cause of subsequent infestation. In the case of Scarlet Mite, leaves falling from the shade trees *Grevillea* and *Albizzia moluccana* are usually infested (Easteal, 1958; Baptist and Ranaweera, 1955). The importance of this has not been critically examined, but it is likely that only a few mites are needed under optimum conditions to build up to an outbreak.

From this brief discussion, it will be apparent that studies are required on the dynamics of mite populations and on the factors in the environment that control and limit their numbers, *i.e.* their whole environment, generally divisible into the interacting factors of climate, predators, food-supply and a place in which to live (Andrewartha and Birch, 1954). Such knowledge would help in planning preventative and curative measures. The fundamental question of practical ecology is 'Why is this pest more abundant here than there?', just as the fundamental question of practical medicine is 'Why is this man sick and not that man?'. At present, it is seldom possible, with any insect pest, to answer this question more than in a very limited way; but it is this knowledge that we seek.

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THE USE OF SEPARATE STICKERS IN BLISTER-BLIGHT FUNGICIDES

D. Mulder

The spraying of tea in plucking poses some special problems:

1. The constant rapid growth causes the continuous development of susceptible unprotected leaf surface.
2. The removal of flush causes the fungicide adhering to the flush also to be removed.
3. The fact that almost all new growth takes place above the level of old sprayed leaves causes redistribution of fungicide by rain to be of only minor importance for the protection of the flush.

The "active" protection period of a fungicide particle on a leaf can for these reasons hardly be longer than one plucking round. Its activity is either finished by the plucking or by the fact that it is situated below the danger zone.

In view of these considerations the use of stickers in tea may be arbitrary. Their effectiveness is limited to the cases in which, immediately after spraying, a heavy shower tends to wash most of the fungicide away to levels where protection is no longer needed. A few days after spraying, so much unprotected new leaf surface has developed that the protective action of the fungicide is finished in any case.

Visser, Shanmuganathan and Sabanayagam (1958) reported that 4 oz. copper oxychloride plus 2 oz. of a sticker did not give better results than other fungicides without addition of the same sticker. Later this sticker was tried and Mulder (1959) reported that no influence on the effectiveness of 3 oz. copper oxychloride could be detected under mild North-East Monsoon conditions. In 1959 the experiment was repeated under South-West Monsoon conditions and again no influence of the addition of stickers could be found.

At this moment, some estates are using sticker with blister-blight spray. It is therefore planned to change two conditions in the experiment to bring out any possible influence of a sticker:—

1. Lower the concentration of the fungicide further to 2 oz. per acre, and test with and without sticker.
2. Lengthen the plucking round.
3. Test the effect of sticker on valuation.

It is hoped that these experiments will finalize the matter.

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RESISTANCE AND TOLERANCE OF TEA TO NEMATODES

M. T. Hutchinson

The name *eelworm* is probably more descriptive of the small animals that feed on tea roots than is the name *nematode,* which means *threadworm.* However, as long as specialists working in this field are called *nematologists,* it may be less confusing to have the animals called *nematodes.*

The problem is how to prevent damage by these nematodes to tea plants. Tea, to one just arrived on the island, is an unusual crop. Chemical treatments which are often relied upon for control of nematodes attacking annual or short-term perennial crops growing on flat lands, are not as well suited to tea. On the other hand, the rather large quantities of organic matter that are available to tea planters from loppings of shade trees and Guatemala grass, as well as composted manures, which probably assist in nematode control, are not to be had in most parts of the world. Resistant and tolerant varieties of plants are, however, one measure commonly used in all areas of the world. In the case of tea, this approach is by far the most important for nematode control.

At this point, a brief history of the discovery of the Meadow Nematode in Ceylon, and of the selection of tea bushes for resistance to this pest may be of interest.

The Meadow Nematode was undoubtedly present in Ceylon before the widespread planting of tea after the destruction of the coffee industry by the rust fungus, *Hemileia vastatrix,* about 1870. In a report on a visit to Mooloya Estate made in 1935, Dr Gadd was informed by the Superintendent that three fields had been affected with Witches Broom from the time of opening in tea, and that it had always been difficult to establish tea there (Gadd, 1935). These fields had previously been in coffee (Sparling, 1939).

This Witches Broom condition of tea, which later proved to be caused mainly by the Meadow Nematode, can be traced back at least to 1925, when a Mr Park described a complex of symptoms under this name in the Year Book of the Ceylon Department of Agriculture (Gadd, 1927). Yellowing of the leaves, spurs with tufts of leaves at the terminals, and small shoots with short internodes and dwarfed leaves, were among the symptoms mentioned. Ten years of experience with this baffling condition led Dr Gadd to discard temporary Witches Broom symptoms associated with a need for pruning, drought, and the presence of the root disease caused by the fungus *Poria hypolateritia.* He stated "There remains, however, a type of bush which exhibits what may be termed the Witches Broom symptoms persistently. They do not respond to cultivation or manuring, and when they are uprooted the roots are seen to be healthy except that there is a deficiency of feeding roots—(the bushes) appear to die very slowly but they are unproductive." (Gadd, 1935).

It was in January, 1939, while examining roots of Witches Broom bushes from Field 1A at Drayton Estate that Dr Gadd first saw the Meadow Nematodes (Gadd, 1939). Mistaking them for the larvae of the Root-knot Nematode, and surprised that there was no swelling of the roots typical of the injury produced by this nematode, he sent specimens to Dr T. Goodey, then the leading British authority

on plant parasitic nematodes. But even before receiving a positive diagnosis of *Anguillulina pratensis* (now *Pratylenchus coffeae*) from Dr Goodey (Gadd, 1939b), Dr Gadd had noted that "odd dark-leafed bushes in this field appeared normally healthy." (Gadd, 1939a).

During the following months, various suggestions were made concerning the propagation of such possibly resistant bushes for supplying infested areas. By January, 1940, selection had apparently begun at Drayton and, after further testing for resistance, yield, and quality, in co-operation with the T.R.I., extensive propagation of a few clones was carried out for use on that estate (Crofts-Bolster, 1947).

In 1950, the Institute began selecting bushes from a large number of estates for testing against the Meadow Nematode (Visser, 1959a). Since that time, cuttings of 78 of these clones have been rooted and from 7 to 10 of each are growing in an infested area at St Coombs. In 1955, 39 of these clones and an additional 30 clones were planted in cement pots (Loos, 1955), and in 1956, were inoculated with Meadow Nematodes. Another complete series was grown in the pots, but not inoculated with nematodes, so as to compare the growth of infested and uninfested plants. Careful evaluation of both field and pot tests has shown that at least 17 of these clones are apparently resistant or tolerant to the Meadow Nematode, and are also good yielders (Visser, 1959a). Eight of them (DK 8, DK 16, DT 1, DT 95, GL 48, K 150, TRI 2142, TRI 2145)[1], also have above average quality (Keegel, 1959). Thus, the selection programme has so far produced about 7 per cent of high quality clones, and has laid an excellent basis upon which work can continue.

Resistance and tolerance

It may be appropriate at this point to define these often-used words: by *resistant* we mean plants that are unsuitable for the normal development or reproduction of the nematodes; by *tolerant* we mean plants in which the nematodes multiply actively, but which are not noticeably harmed by this. *Immunity*, where the plant is in no way a host for a particular pest, is rarely encountered in selection programmes. More work will be needed before we can say whether or not certain tea clones are actually immune to Meadow Nematodes.

There are several ways in which a tea plant could be resistant to the Meadow Nematode. These can best be shown by tracing the progressive steps by which such nematodes become established in plant roots. Before entry into roots, Meadow Nematodes explore the root surface for suitable entry sites. A chemical sense seems to be involved here. On locating a suitable site, the nematode proceeds to pierce the root epidermis with its hollow stylet, which very much resembles a hypodermic needle and which is directly connected with the nematode's throat or oesophagus. Because of slack in the oesophagus, the stylet can be extended or retracted from the mouth opening. The task of piercing the root surface is somewhat comparable to piercing a thick sheet of leather with an awl, and may explain why the Meadow Nematodes prefer to enter the less mature parts of the root just above the growing tip (Gadd and Loos, 1946).

Once the root is pierced, the nematode may feed on the liquid contents of the cells of the cortical layer, which it sucks up through the stylet by means of a pump located in the oesophagus. Then, by repeated thrusting of the stylet in the same area, the root epidermis is sufficiently weakened to enable the nematode to batter the root with its head, with some prospect of thrusting through into the opening produced. Once this is accomplished, the nematode moves easily into the cortex, where the cells offer virtually no resistance to further movement within the root. The fact that entry thus requires a considerable expenditure of energy may explain

[1] DK = Diyanilakele, DT = Drayton, GL = Glassaugh, K. = Kirkoswald.

why starved Meadow Nematodes cannot enter tea roots after 9 weeks, although they will live for more than 18 weeks (Gadd, 1942).

From this description, it is evident that resistance to entry could depend upon lack of chemical attractiveness or actual repellency or toxicity of the root surface to the nematode. The same could be true of the contents of the cells of the cortex. Or the root epidermis could be unusually tough and difficult to penetrate. Such resistance, it should be noted, implies only that *most* of the Meadow Nematodes will be prevented from entering, but that since individual nematodes differ from one another just as individual human beings do, a very few may be capable of entering. If none are capable of entering, then the plant is truly immune, at least until a type of nematode that can enter is produced.

Once having entered, the nematodes may encounter other types of resistance. The cell contents may not be such as to nourish the nematodes, and this may result in their leaving the root. The cell contents may be inhibitory or even toxic to them. This could result in young nematodes not completing the three moults required for maturity, or in the adult nematodes not being as fertile as usual. At this point, only a few of the twenty or so eggs normally produced may be deposited and these eggs may fail to hatch.

There are thus three major ways in which a tea plant can be resistant to the Meadow Nematode. It may resist entry of the nematodes. It may resist feeding and growth of the nematodes. It may resist the production and deposition of a normal number of fertile eggs. A single plant species, such as *Crotalaria anagyroides*, may show more than one type of resistance. According to Gadd and Loos (1941), although many female Meadow Nematodes entered the roots of this plant, most of them left again without depositing eggs. Very few of the eggs that were deposited actually hatched, and the larvae that did hatch matured much more slowly than normal.

As regards tolerance, there are also several possibilities, though not as many as for resistance. First, the roots may not be injured by the feeding of the nematodes. In the process of feeding, secretions from the glands that empty into the oesophagus of the nematode are pumped into the cells before the cell contents are sucked out. In the case of the meadow nematode, these secretions are usually toxic to the plant cells, the death of which produces the discoloured areas known as *lesions*; another name for the Meadow Nematode is the Root-lesion Nematode. Second, tolerance could depend on the rapid repair of mechanical damage to the plant. The Meadow Nematodes wander around inside the root and they pass through cell walls as well as around them. In its extreme form, this activity can result in a shredding of the insides of the root. Third, if the roots are definitely injured by the glandular secretions or movements of the nematodes, or both, the plant may be so vigorous as to put out roots faster than the nematodes can attack them. This sort of tolerance may cease to have a practical effect when the available soil volume is completely filled with roots, and when sufficient time has elapsed for the nematodes to become established in all parts of the root system.

It will thus be evident that tolerance is theoretically less desirable than resistance, since it does not check the nematode population, which can go on building up inside the roots, largely protected from natural enemies.

Further testing of resistant and tolerant clones

We have two major projects in mind for the further testing of clones.

The first is to determine what types of resistance are available in clones so far selected. This will be done in the laboratory, by growing rooted cuttings in soil in small glass dishes and inoculating them with Meadow Nematodes collected at St Coombs and other estates. The progress of the nematodes will be carefully

observed and comparisons will be made with clone TRI 2024, which is very susceptible to nematode attack. This work can then serve as a basis for testing additional clones selected by estates or by T.R.I. staff as being apparently resistant. Such an initial test could result in the discarding of clones that were not worth further testing in the field, and thereby speed up the selection programme. Visser (1959) summarizes the results of research to determine the resistance to Meadow Nematode of the cover crops and shade trees used on tea estates.

The second project involves testing the clones already selected, against as many as possible of the Meadow Nematode populations that they are likely to encounter upon widespread distribution.

Considerable experience with plant resistance to nematodes has shown that a selection resistant to one nematode population can be quite susceptible to another of the same species. This problem can be important even with annuals such as potatoes (Jones, 1957), or short-term perennials such as alfalfa (Goplen *et al*, 1959). With a crop such as tea, that may not be replanted again for another fifty years or more, there are fewer opportunities for correcting mistakes.

This idea of testing clones against several populations of Meadow Nematodes is not a new one, since attempts were made at four estates (Dambatenne, Diyanilakele, Kirimetiya and Mooloya) beginning in 1955 to establish resistant and tolerant clones (Loos, 1956). By 1956, 167 clones were under test (Webster, 1957), but for various reasons these trials have not been fully successful. However, the clones remaining in these plantings will be evaluated as a first step in testing their resistance to various populations of Meadow Nematodes. Later, a few of the most resistant clones will be tested in pots against many different populations, and a long-range experiment to determine the value of tolerance under field conditions will be established at St Coombs.

That some tea clones may be resistant to one population of Meadow Nematode and susceptible to others is shown by the different results obtained with some clones when they were tested in the field plot at St Coombs, and in the cement pots. The nematode populations used for inoculating the pots came from Eildon Hall and Diyanilakele estates, since in 1956 sufficient nematodes could not easily be found at St Coombs. The field plots, on the other hand, had a population presumably native to St Coombs. Clone TRI 2135, selected at St Coombs, proved to be practically immune in the field plot. However, it eventually proved to be quite susceptible in the pot test (Visser, 1959a), and is therefore not known at present to be resistant except to the St Coombs population. By contrast, DT 95, selected for apparent resistance at Drayton Estate, has proved to be highly resistant in both the field plot and pot tests. Likewise, a preliminary survey indicates that it grows well in infested areas at Mooloya Estate and supports very few Meadow Nematodes. This clone is therefore probably resistant to at least five populations of Meadow Nematode.

After learning from the laboratory tests what types of resistance are available, crossing of plants having various types of resistance could make the progeny much more resistant to present and future nematode populations.

Resistance and tolerance to other nematodes

So far, I have dealt only with the Meadow Nematode, *Pratylenchus coffeae*, which is the principal nematode pest of Ceylon tea. As far as we know, there is only the one species here, but in the world as a whole, there are at least fifteen different species of Meadow Nematodes all of which can be damaging to crops. In Ceylon tea, there are also the Root-knot Nematodes of the genus *Meloidogyne* to contend with. One of these, *M. javanica*, attacks only young tea, while *M. brevicauda* also attacks mature tea (Loos, 1953). *M. javanica* is widely distributed throughout the

tea-growing areas of the island, whereas *M. brevicauda* is known to be present on only three estates within nine miles of each other. Thus, neither nematode is at present a serious threat to the industry. However, times may change. *M. javanica* may adapt to mature tea, and *M. brevicauda* may spread to different parts of the island. It would therefore be desirable to test clones against both of these Root-knot Nematodes. Also, it is desirable to prevent spread not only of *M. brevicauda*, but likewise of *M. javanica* and *Pratylenchus coffeae* by not moving soil or plants from one estate to another.

At this point, we must prepare planters for what may prove to be other nematode pests of tea. There appear to be at least five additional nematodes that are found even more frequently associated with tea roots than either the Meadow or the Root-knot Nematodes. These belong to groups whose common names are *pin* and *spiral* nematodes. In contrast to the Meadow and Root-knot Nematodes, they feed from the outside and rarely enter the roots. Three of these five were noted by Gadd (1946, 1947), but no work has been done to determine whether or not they will multiply on tea and, if so, whether or not they are harmful. If one or more should prove harmful to tea, it would be desirable to test clones for resistance or tolerance to them. Another need would then arise, namely, to determine whether or not Guatemala grass and marigolds are as resistant to these nematodes as they are to the Meadow and Root-knot Nematodes. In these plants, used for reconditioning tea soils, tolerance may not be enough, particularly if the nematode populations are built up to a point where the tea subsequently planted is injured.

The role of surveys

It has been supposed that the low-country of Ceylon is not particularly troubled with Meadow Nematode. According to our recent survey of a total of 14 estates in the Balangoda, Ratnapura, Rakwana, Morawak Korale, Kalutara, and Galle Districts, this supposition is correct. Should further survey of these and similar districts confirm the virtual absence of Meadow Nematodes, or rather their apparent inability to multiply in these areas, it will probably not be necessary to consider resistance or tolerance to this pest when selecting clones for these areas. On the other hand, *M. javanica* and the Pin and Spiral Nematodes appear to be just as widely distributed there as in the high country.

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FURTHER SMALL-SCALE FIELD EXPERIMENTS ON THE CHEMICAL CONTROL OF ATTACK BY SHOT-HOLE BORER *(XYLEBORUS FORNICATUS* EICH.) ON TEA IN PLUCKING

E. Judenko

Preliminary field trials on the chemical control of Shot-hole Borer of tea were described in a previous paper (Judenko, 1958a). It was reported that, associated with the known activity of the beetles in the lower parts of tea bushes, spray applications to the lower parts of tea bushes in plucking, using high dosages of dieldrin and chlordane, were effective in reducing borer populations for up to nine months after treatment. These high dosages may, of course, be uneconomic. In the present paper, results are reported from a further series of small-scale field trials designed to assess the effects of lower dosages of the insecticide applied in the same way, under varied climatic conditions.

Details of trials

Sixteen small-scale field trials were carried out on twelve estates in the low-country and the mid-country. Each trial (except 62/57) was of a randomized-block design with five replicates of four plots each; the exception (62/57) is an earlier experiment done at Rye Estate and partly described as Experiment 1 in Table 2 by Judenko (1958a). In fourteen of the trials, in addition to the plots with the experimental dosages of insecticide, there were, for comparison, both unsprayed plots and also plots sprayed with a very high dosage of dieldrin (6-14 lb. in 130-270 gal. of water per acre), previously designated *maximum-kill* treatments (Judenko, 1959). Large amounts of rain fell between spraying and assessment, varying from 24″ in five months in No. 14 of Table 2 to 216″ in 25 months in No. 10 of Table 1.

Trials were planned to cover a range of experimental dosages from 0.7 to 5.5 lb. of dieldrin per acre and 1.9 to 20.8 lb. of technical chlordane per acre, usually applied in about 100 gal. of water per acre. Dieldrin was used as a proprietary miscible oil formulation which contains certain resins, designed to give additional weathering properties (*Dieldrex Extra*). Chlordane was used as a 50* proprietary miscible oil formulation (*Clordox*). Spraying was carried out using Birchmeier *Automat* self-acting knapsack sprayers fitted with single Horto-Sapphire fog nozzles of 0.55 mm. orifice; in experiment 62/57, however, *Duro* nozzles, of 1.65 mm. orifice, were used instead. Applications to the maximum-kill plots were always made with the *Duro* nozzles, to give a higher gallonage per acre.

*The suppliers state that *Clordox* contains 10 lb. of active ingredient per gallon.

TABLE 1.—*Percentage reductions in Shot-hole Borer infestations after spraying with chlordane (Chlord) and dieldrin (Dldrn)*

No.	Expt.	Estate (height of spraying)	Chem.	Dosage lb. and gal. per acre	Date of spray	Condition of bush (rain)	Counts made: months after spray	No. of live adults in control	% reduction in live adults
1	12/58	Kuattpitiya (1½′)	Chlord	19.2 (128)	25.3.58	dry (0.55″)	8	231	67
2	,,	,,	,,		,,		14	520	44
3	,,	,,	Dldrn	6.8 (135)	24.3.58	dry (0.08″)	8	231	87
4	,,	,,	,,		,,		14	520	83
5	,,	,,	Dldrn	13.6 (271)	25.3.58	dry (0.55″)	8	231	82
6	,,	,,	,,		,,		14	520	85
7	62/57	Rye (½′)	Chlord	38.3 (102)	10.9.57	wet (0.30″)	18	263	77
8	,,	,,	,,		,,		25	607	45
9	,,	,,	Dldrn	5.4 (109)	9.9.57	dry (0.14″)	18	263	91
10	,,	,,	,,		,,		25	607	62
11	7/58	Alupolla (1′)	Chlord	15.3 (102)	18.2.58	dry (0.39″)	9	289	47
12	,,	,,	,,		,,		15	662	33
13	,,	,,	Dldrn	5.1 (102)	24.2.58	dry (0.41″)	9	289	77
,,	,,	,,	,,		,,		15	662	72
15	,,	,,	Dldrn	12.1 (242)	19.2.58	dry (0.46″)	9	289	92
16	,,	,,	,,		,,		15	662	70
17	1/58	Niriella (1′ & 1½′)	Chlord	14.9 (99)	16.1.58	dry (0.23″)	4	64	0
18	,,	,,	Dldrn	5.1 (102)	15.1.5	dry (0.09″)	4	64	86
19	,,	,,	Dldrn	9.8 (195)	15.1.58	wet (0.09″)	4	64	78
20	9/58	Pelmadulla (1½′)	Chlord	16.1 (107)	4.3.58	dry (nil)	7	41	63
21	,,	,,	Dldrn	4.9 (99)	3.3.58	dry (0.03″)	7	41	85
22	,,	,,	Dldrn	11.6 (223)	3.3.58	dry (0.03″)	7	41	85

NOTES.—1. In the seventh column is given the amount of rain that fell on the day of spraying *after* spraying had been done.

2. Dieldrin at roughly 5 lb. per acre, even though applied just before rain of up to 0.41″, produced considerable reductions in beetles 14 to 15 months and even 25 months after spraying; heavier dosages of dieldrin produced no better results.

3. The results of spraying with chlordane were always inferior to those with dieldrin at similar cost.

TABLE 2.—*Percentage reductions in Shot-hole Borer infestations after spraying with moderate dosages of dieldrin or chlordane (marked*)*

No.	Expt.	Estate (height of spraying)	Dosage lb. and gal. per acre	Date of spray	Condition of bush (rain)	Counts made: months after spray	No. of live adults in control	% reduction in live adults
1	6/59	Hantane (1½′)	3.3 (133)	28.1.59	dry (nil)	5	97	98
2	,,	,,	12.0 (240)	27.1.59	dry (nil)	5	97	97
3	8/59	Oodewella (1′)	3.2 (128)	7.2.59	dry (nil)	5	85	95
4	,,	,,	10.8 (216)	6.2.59	dry (nil)	5	85	98
5	10/58	Watapota (1½′)	*9.6 (128)	10.3.58	dry (0.78″)	4	195	7
6	,,	,,	3.1 (122)	11.3.58	wet (5.42″)	4	195	32
7	,,	,,	13.4 (268)	11.3.58	wet (5.42″)	4	195	56
8	9/59	Oodewella (1′)	2.9 (115)	11.2.59	dry (nil)	6	83	96
9	,,	,,	11.6 (232)	10.2.59	dry (nil)	6	83	99
10	7/59	Hantane (1½′)	2.8 (112)	30.1.59	dry (nil)	8	54	59
11	,,	,,	12.5 (250)	3.2.59	wet (nil)	8	54	98
12	6/58	Mahawela (1′)	*6.8 (91)	13.2.58	dry (nil)	8	86	53
13	,,	,,	2.3 (91)	13.2.58	dry (nil)	8	86	86
14	10/59	Bandarapola (1′)	2.1 (83)	21.2.59	Very wet (0.06″)	5	22	0
15	,,	,,	8.3 (167)	20.2.59	wet (0.66″)	5	22	82

NOTES.—1. In the sixth column is given in brackets the amount of rain that fell on the day of spraying *after* the spraying had been done.

2. The chemical insecticide used was dieldrin except in the cases starred,* namely, numbers 5 and 12, where it was chlordane. The chlordane was less effective than an amount of dieldrin of similar cost.

3. The effectiveness of dieldrin was much reduced by wetness of the bushes at the time of spraying (Nos. 6 and 14).

4. When the bushes were dry at the time of spraying, the trial dosages of roughly 2-3 lb. of dieldrin per acre generally gave control similar to that of the maximum-kill dosages of 8-12 lb. per acre. No explanation is available for getting only 59% reduction in No. 10.

TABLE 3.—*Percentage reductions in Shot-hole Borer infestations after spraying with low dosages of dieldrin*

No.	Expt.	Estate (height of spraying)	Dosage lb. and gal. per acre	Date of spray	Condition of bush	Counts made: months after spray	No. of live adults in control	% reduction in live adults
1	11/59	Bandarapola (1′)	1.8 (70)	26.2.59	dry	7	25	80
2	,,	,,	6.6 (133)	25.2.59	dry	7	25	92
3	6/59	Hantane (1½″)	1.4 (138)	27.1.59	dry	5	97	85
4	,,	,,	12.0 (240)	27.1.59	dry	5	97	97
5	8/59	Oodewella (1′)	1.2 (120)	6.2.59	dry	5	85	85
6	,,	,,	10.8 (216)	6.2.59	dry	5	85	98
7	7/59	Hantane (1½′)	1.1 (104)	3.2.59	wet	8	54	39
8	,,	,,	12.5 (250)	3.2.59	wet	8	54	98
9	9/59	Oodewella (1′)	1.1 (104)	10.2.59	dry	6	83	94
10	,,	,,	11.6 (232)	10.2.59	dry	6	83	99

NOTES.—1. In none of these experiments was there any rain on the day of spraying but in Nos. 7 and 8, 1.09″ fell on the day before.

2. There was not much difference, except when spraying on wet bushes, as in No. 7, between the results from low dosages of 1.1 to 1.8 lb. per acre and the maximum-kill dosages of 6 to 12 lb. per acre.

TABLE 4.—*Percentage reductions in Shot-hole Borer infestations after spraying with very low dosages of dieldrin and chlordane (marked*)*

No.	Expt.	Estate (height of spraying)	Dosage lb. and gal. per acre	Date of spray	Condition of bush (rain)	Counts made: months after spray	No. of live adults in control	% reduction in live adults
1	10/59	Bandarapola (1′)	0.8 (73)	20.2.59	wet (0.66″)	5	22	50
2	,,	,,	8.3 (167)	20.2.59	wet (0.66″)	5	22	82
3	4/58	Galbode (2′)	*2.3 (151)	12.2.58	dry (nil)	2	126	13
4	,,	,,	0.8 (148)	12.2.58	dry (nil)	2	126	36
5	,,	,,	11.7 (234)	29.1.58	dry (0.62″)	3	126	78
6	11/59	Bandarapola (1′)	0.7 (68)	25.2.59	dry (nil)	7	25	64
7	,,	,,	6.6 (133)	25.2.59	dry (nil)	7	25	92
8	11/58	Denawaka (1′)	*1.5 (102)	15.3.58	wet (0.89″)	7	27	0
9	,,	,,	0.6 (109)	14.3.58	dry (0.64″)	7	27	33
10	,,	,,	11.2 (224)	18.3.58	dry (0.64″)	7	27	89

NOTES.—1. In the sixth column is given in brackets the amount of rain that fell on the day of spraying *after* the spraying had been done.

2. The insecticide used was dieldrin, except in the cases starred,* namely, Nos. 3 and 8, when it was chlordane. The chlordane was less effective than dieldrin of similar cost.

3. The trial dosages of dieldrin of 0.6 to 0.8 lb. in 68 to 148 gallons of water per acre gave control that was definitely inferior to that of the maximum-kill dosages of 6.6 to 11.7 lb. per acre.

Spraying was carried out only on the lower parts of the bushes. If the average height of the tea was 3 ft. or less, the bushes were sprayed to a height of 1 ft. above ground level; if the bushes averaged more than 3 ft. in height, spraying was done to a height of $1\frac{1}{2}$ ft. above ground level. Two instances outside this rule are noted in the tables of results. Only one spraying round was made, at times varying from six to twenty-one months after the dates of pruning in the various fields used (except in experiment 62/57 when it was done one month after pruning). The precautionary measures used in the handling of the insecticides have been described previously (Judenko, 1958a) except that, in addition, spraying operators wore rubber boots, in accordance with the recommendation of the Planters' Association Estate Health Scheme.

Records were kept of whether the woody parts of the bushes were wet or dry before spraying, and of the rainfall on the same day, after spraying, and until assessment was completed.

Assessments of shot-hole-borer populations were carried out as comparisons of numbers of adult beetles in equal numbers (100–400) of prunings from treated and untreated plots, except in Experiment No. 5/58, when 75 *standard units* were dissected in each case (Judenko, 1958). Assessments were carried out once or twice in each trial, at times varying in the different trials from 2 to 25 months after spraying.

TABLE 5.—*Number of Shot-hole Borers (adults) in* 75 *standard units before and after spraying. Galbode Estate. Sprayed on* 11-2-58, *at* $1\frac{1}{2}'$ *above ground. There was no rain on the day before the spraying and the wood was dry, but* 0.21″ *fell on the day of spraying. In brackets are shown the percentage increases in beetle numbers compared with the numbers before spraying*

No.	Time	Control	Chlordane 1.6 lb. in 104 gal. of water per acre	Dieldrin 0.7 lb. in 130 gal. of water per acre	Dieldrin 9.8 lb. in 195 gal. of water per acre
1	Before spraying	4	11	17	10
2	At $2\frac{1}{2}$ months after spraying	28 (600%)	24 (118%)	7 (—59%)	2 (—80%)
3	At 6 months after spraying	22 (450%)	35 (218%)	14 (—18%)	0 (—100%)

NOTE.—As in Table 4, the very low dosage of dieldrin used did not reduce the population as much as the maximum-kill dosage. Again, chlordane was less effective than dieldrin at comparable cost.

Results

(1) The results of one trial (8/57 at Pelmadulla) are not given, the number of beetles having been too low to justify any conclusions. The remaining results are given in Tables 1 to 5; some of the maximum-kill controls are given more than once in Tables 2–4.

(2) In Tables 1–4, the numbers of beetles found by sampling the experimental treatments and the maximum-kill controls have been expressed as percentage

reductions of the number found in the untreated control on each occasion. These percentages are given in the last column of each of the tables 1–4. The actual numbers of beetles found in the untreated control are also given (last column but one), as an indication of the degree of infestation.

(3) The effect of climatic conditions on the day of spraying was very marked; in the tables is recorded whether conditions were wet or dry. Wet conditions are here defined as those in which the woody parts of the bushes were wet when the spray was applied. If rain fell *after* spraying on the same day, the amount is recorded in the same column. No conclusions can be drawn concerning the effect of the amount of rain after the day of spraying, except that, provided initial conditions were dry, it did not appear to affect the result greatly. Data on subsequent rainfall are therefore omitted from the tables.

(4) The results of nine trials that were begun in 1958 showed clearly that chlordane was markedly inferior in effect to dieldrin when compared at dosages of the same cost (based on prices at Colombo in early 1958, namely, Rs. 6.50 per lb. of technical chlordane and Rs. 20/- per lb. of active ingredient of dieldrin). Chlordane was therefore omitted from the later trials.

(5) Dosages of dieldrin as low as 1.1 lb. per acre applied in about 100 gallons of water per acre usually worked well when the woody parts were dry at the time of spraying (exception—No. 10 in Table 2). In these circumstances, 1.1–3.3 lb. of dieldrin per acre gave results only slightly less good than those of the maximum-kill controls at 10-14 lb. of dieldrin per acre. Results from using 0.6–0.8 lb. of dieldrin per acre were inferior and this dosage is evidently too low even in dry conditions; 1½ lb. per acre would appear to be a reasonable minimum.

(6) When spraying was carried out when the branches and stems of bushes were already wet, dosages of below 8 lb. gave poor results and even the maximum-kill control at over 13 lb. was not as good as with dry wood at spraying time (*e.g.* Table 2, No. 7). If the wood was dry when sprayed but some rain fell later in the same day, there seemed to be some reduction in effectiveness, both at 5 lb. and at around 12 lb. per acre, but this is quite uncertain.

Summary and Conclusions

The results are reported of sixteen small-scale field trials on the chemical control of Shot-hole Borer (*Xyleborus fornicatus* Eich.) in tea. Only the lower parts of the bushes were sprayed, up to a height that depended on the height of the bush and was never more than two feet. Chlordane was markedly inferior in effect to dieldrin when compared at dosages of the same cost. The minimum effective dosage of dieldrin was 1.1 lb. in about 100 gal. of water per acre; this gave results roughly comparable with those from over 10 lb. of dieldrin in about 200 gal. of water per acre when applied on dry days. If the woody parts of the bushes were already wet when the spray was applied, the minimum effective dosage was 8 lb. per acre. Rain *after* spraying, but on the same day, seemed to have a slightly detrimental effect on the results.

The results permit the planning of large-scale experiments on the influence of dieldrin sprays on (*a*) yield of tea (*b*) insecticide residues in made tea (*c*) taint (off-flavour) and quality of made tea (*d*) side effects on other tea pests, notably Tea Tortrix (*Homona coffearia* Nietn.) by destruction of the parasite *Macrocentrus homonae* Nixon.

No practical recommendations on the use of dieldrin can yet be made.

Acknowledgments

I am grateful to the Superintendents of estates for facilities for carrying out these experiments and to Mr C. Shanmugan, my Assistant, for his part in the work.

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SUMMARY MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD IN THE GENERAL COMMITTEE ROOM OF THE PLANTERS' ASSOCIATION OF CEYLON, 73/1, KOLLUPITIYA ROAD, COLOMBO, AT 9 A.M. ON FRIDAY, 4TH DECEMBER, 1959.

Present.—Mr F. Amarasuriya (Chairman), Messrs G. I. de Glanville (Chairman, Agency Section, Planters' Association of Ceylon), H. Creighton (Chairman, Planters, Association of Ceylon), H. E. Peries, O.B.E., C.C.S. (Deputy Secretary to the Treasury), B. Mahadeva, C.C.S. (Tea Controller), R. C. Scott, C.B.E., J. L. D. Peiris, R. M. Macintyre, R. J. Gilmour, R. D. Wedd, E. Jayawickreme, D. E. Hettiarachchi, Senator Reginald Perera, Messrs W. H. W. Coultas, N. M. Sanders, Dr D. L. Gunn, C.B.E. (Director), Messrs H. J. Balmond (Chief Administrative Officer) and G. A. D. Kehl (Administrative Secretary).

Mr C. Selwyn Samaraweera intimated his inability to be present.

The Chairman welcomed Dr D. L. Gunn (Director), Messrs G. I. de Glanville (Chairman, Agency Section, Planters' Association of Ceylon), who were present for the first time, and R. C. Scott, C.B.E., R. J. Gilmour and R. D. Wedd on return from leave.

The Chairman, on behalf of the Board, congratulated Senator Reginald Perera on his being elected to the Senate.

1. **Minutes of the Meeting held on 4th September, 1959**

The minutes of the meeting of the Board held on 4th September, 1959, were confirmed subject to the following corrections:—

(a) **Page 8—Draft Minutes of Administrative Committee meeting of 15th August, 1959**

(3) **Page 6—Item 5 (a)—Institute Insurances**

Last line: after the words "Companies" add the following:—

"and endorsed the recommendations of the Administrative Committee."

(b) **Page 9—2nd paragraph lines 7, 8 and 9**

Delete the last two sentences of this paragraph "at the same time it was a matter of doubt...........and was not a Government-owned Bank" and substitute:—

"The Bank of Ceylon was not a Government-owned Bank, but set up under Ordinance No. 53 of 1938, Government subscribing one-third of the share capital, with three Government nominated Directors. The remainder of the shareholders were private individuals."

2. Matters Arising from the Minutes

(1) Page 3 — Item 3 (7) — Scientific Advisory Committee in the U.K.

The Director reported that he had received a cable from Dr Tubbs stating that four persons had been invited to serve on the Committee and that the Committee would start on 1st January, 1960.

In reply to Mr Sanders, the Director said that the invitees were Sir Joseph Hutchinson, F.R.S., Professor of Agriculture, Cambridge, Mr F. C. Bawden, F.R.S., Director of Rothamsted Experimental Station, Professor T. A. Bennet-Clark, F.R.S., Professor of Botany in King's College, London, and Dr Tubbs himself as Chairman and Convener. The invitations to the two remaining vacancies were under discussion.

(2) Page 3 — Item 3 (8) — Dr Pearce's Report

The Director said that Dr Pearce's report was a very thorough and sound piece of work. Copies were available for distribution to those members of the Board who desired to have copies. The principal matters arising from the report had been discussed by the Experimental and Estate Committee which had recommended the addition of two senior members to the staff: a chief agronomist, who would be responsible with the specialist scientists for field experiments, and a statistician who would assist in planning and evaluating the experiments. He proposed that the Board record its appreciation of the work done by Dr Pearce and Dr Tubbs in the form of the following resolution:—

> "The Board values highly the report received from Dr Pearce and records its appreciation of the interest and effort of Dr Tubbs in arranging for the investigation, and its appreciation of the work done by Dr Pearce and the promptness of his reporting."

The Board agreed.

(3) Page 4 — Item 3 (10) — Plant Breeder

The Director reported that all three applicants for this post had obtained other employment and that the post had been re-advertised.

(4) Page 10 — Item 9 — Instant Tea

The Director's report was received.

(5) Page 10 — Item 9 — Study Groups

Reported that the proposal was referred to the Experimental and Estate Committee and that a sub-committee, with Dr Hutchinson as Convener, had been appointed to report on the proposal. The report was received.

(6) Page 13 — Item 10 (2) — Administrative Committee

Reported that the Administrative Committee at its meeting held on 16th October, had discussed the problem fully and it had been suggested that a suitable procedure be adopted for minimising administrative delays and that in accordance with this proposal the minutes of the Administrative Committee of 16-10-59 had been circulated to the Board for approval. Paper No. B68/59 explained the procedure fully.

The Director said that the procedure would reduce considerably the paper work of the Board. The procedure could, however, be discussed later under item 5 of the agenda. The report was received.

3. Membership of the Board and Committee

(a) Board

(1) Reported that Mr G. I. de Glanville, on election as Chairman of the Agency Section of the P.A., became an *ex-officio* member of the Board as from 7-10-59, vice Mr C. D. Green.

(2) Reported that Mr R. J. Gilmour had returned from leave and had assumed his seat on the Board as from 4-10-59, relieving Mr A. D. McLeod who was acting for him.

(3) Reported that Mr R. D. Wedd had returned from leave and had resumed his seat on the Board as from 14-10-59.

(4) Reported that Mr R. C. Scott, C.B.E., had returned from leave and had resumed his seat on the Board as from 4-12-59 relieving Mr R. C. P. Adams who was acting for him.

(b) Committees

(1) ADMINISTRATIVE COMMITTEE

Reported that Mr R. D. Wedd has resumed his seat on the Administrative Committee as from 14-10-59, relieving Mr R. M. Macintyre who was acting for him.

(2) APPOINTMENTS COMMITTEE

Mr G. I. de Glanville was nominated to fill the vacancy on this Committee, vice Mr C. D. Green who vacated his seat on the Board when he relinquished the Chairmanship of the Agency Section of the Planters' Association.

(3) EXPERIMENTAL AND ESTATE COMMITTEE

Reported that:—

(1) Mr P. S. Gray would take the place of Mr C. M. G. Moberly as from 1-1-60.

(2) Mr A. E. A. Wallace-Tarry would take the place of Mr R. C. P. Adams as from 1-1-60.

(3) Mr A. D. Neale would act for Mr A. J. Pelly Fry during the latter's absence on leave for six months as from 1-1-60.

The Chairman thanked the outgoing members for their services to the Board' and welcomed the new members and those returned from leave.

4. Finance

(a) Institute's accounts as at 31st October, 1959

The Institute's accounts as at 31st October, 1959, were adopted.

(b) Director's memorandum on the Institute's Budget for 1960

The Director's memorandum was discussed fully.

Mr Gilmour proposed, seconded by Mr Wedd, that the Director's memorandum on the Institute's Budget for 1960 be adopted, subject to the deferment of the last paragraph relating to an increase in cess for consideration at the next Board meeting. The proposal was carried.

(c) Draft Estimates for 1960

(1) RESEARCH REVENUE AND CAPITAL ESTIMATES INCLUDING ESTATE CAPITAL EXPENDITURE

The Chairman stated that these estimates had been carefully scrutinised by the Administrative Committee at its last meeting and the amendments recommended by the Committee had been incorporated in the draft estimates tabled for the consideration of the Board.

(2) ESTIMATES OF ESTATE REVENUE EXPENDITURE

Mr Coultas said that these estimates had been scrutinised firstly by a sub-committee of the Experimental and Estate Committee and then by the Experimental and Estate Committee which had recommended their approval. The Sub-Committee had done an excellent job, resulting in a C.O.P. that was comparable with that of a commercial estate of the same size and he proposed a vote of thanks to the Committee. Mr Gilmour seconded the proposal. Agreed.

On the proposal of Mr Gilmour, seconded by Mr Coultas, the Board adopted the draft estimates for 1960 *in toto*.

5. Principle of Circulation of Papers to the Board

The Director's memorandum was discussed. The general opinion of the Board was that all papers should be circulated to them, though nobody should be sent more than one copy. Mr Gilmour suggested that, if minutes had to be amended, only the amended page need be circulated. Agreed.

Agreed that all minutes of Committees be circulated to the Board.

6. Low-Country Sub-Station

The Director reported that Dr Joachim had taken up residence in Ratnapura, some ten miles away from Mutwagalla. A formal request had been made to the Government Agent, Ratnapura, on 15th November for the acquisition of 50 acres. (Approval of the Board had been received by circulation of Papers A.51/59 and A.56/59). An early agreement was envisaged; meanwhile preparations for the work would go on. The entire top floor of the factory would be used for laboratory and office without disturbing the working of the factory, and the planning and designing had already started. This procedure might involve the Institute in some loss if acquisition proceedings failed, but it would save loss of time and it was the view of the Administrative Committee that the risk should be taken.

The report was received and the Board approved the action taken.

7. Mid-Country Clonal Proving Station

The Director reported that, after much difficulty, a suitable site for this sub-station had been selected on Hantane Estate. The land required on lease for experimental work had been marked out with the co-operation of the Superintendent and the decision of the agents was awaited.

On the proposal of Mr Errol Jayawickreme, seconded by Mr D. E. Hettiarachchi, the Board approved the action taken by the Director towards establishing a mid-country clonal proving station.

It was agreed that when the draft lease was ready, papers should be circulated to the Board for approval of the terms and for authority to use the Board's seal on the document.

8. Minutes of the Meeting of the Appointments Committee held on 18th September, 1959

Reported that the recommendations of this Committee in respect of a Research Assistant in Agricultural Chemistry (Mr K. P. G. S. W. Karunaratne) and the re-appointment of Dr A. W. R. Joachim as Low-Country Adviser had been approved by the Board by circulation of papers (Circulars No. A.54/59 and A.55/59). The minutes were approved.

9. Minutes of the Meetings of the Administrative Committee held on 16th October, 1959 and 21st November, 1959

(a) Minutes of Meeting of 16-10-59

Reported that the minutes of the meeting of the Administrative Committee held on 16th October, 1959, had been circulated to the Board and had been approved with the exception of the following items:—

(1) Item 3 (2) — Requests for carpets, etc.

(2) Item 8 (6) — Mr E. N. Perera — Provident Fund.

These items were being brought up for discussion under Item 12 of the agenda. The report was received.

(b) Draft minutes of meeting of 21-11-59

PAGE 3 — ITEM 3 (3) (*c*) — PHOTO ELECTRIC CONTROL OF FACTORY

Agreed that sub-section 3 of the recommendations in paragraph 3 of item 3 (3) (*c*) be amended as follows:—"The Colombo Assurance Company should arrange for an adequate periodical inspection of the factory, preferably by a representative of the Ceylon Fire Insurance Association, and should keep in mind the experimental work being carried out in the factory."

PAGE 2 — ITEM 3 (1) (*a*) — ESTATE WORKING ACCOUNT AS AT 30-9-59

Reported that the words "that month" in the last line of the minute had been amended to read "this year". Agreed.

The draft minutes of the Administrative Committee held on 21-11-59 were then approved subject to the above amendments.

10. **Summary of Recommendations from Experimental and Estate Committee Minutes of 7-11-59**

The Director reported that the main points had already been dealt with and that these minutes would be circulated to the Board.

Mr Gilmour suggested that, if a suitable agricultural economist was not available, consideration might be given to obtaining the services of a cost accountant for this purpose.

The summary of the recommendations of the Experimental and Estate Committee were approved on the proposal of Mr Sanders, seconded by Mr Wedd.

11. **Resolution for the Use of the Board's Seal**

(*a*) It was reported that the Board's seal had been affixed to:

(1) the contract for the construction of new buildings at St Coombs with Messrs Brown & Co., Ltd.;
(2) the contract for the construction of stage II of the water supply scheme with Messrs Brown & Co., Ltd.

(*b*) On the proposal of Mr N. M. Sanders, seconded by Mr R. D. Wedd, the Board approved the draft Deed of Transfer to be executed in favour of the Board by the Lindoola Tea Company Limited, in respect of the allotment of land in extent 37 perches which was recently conveyed by the Board to the Vendor Company by way of Exchange No. 42 dated 30th September, 1957, attested by Mr J. A. R. Weerasinghe, and authorised the use of the Board's Seal on this document.

(*c*) On the proposal of Mr J. L. D. Peiris, seconded by Mr W. H. W. Coultas, the Board approved the transfer of Rs 120,000/- stock, Ceylon Government $3\frac{1}{2}\%$ Loan 1959-64, and Rs 130,000/- Stock, Ceylon Government $3\frac{1}{2}\%$ Loan 1961-63 from the Tea Research Institute Small Holdings Advisory Service to the Tea Research Institute Account, and resolved that the Board's Seal be used on the documents relating to this transfer.

12. **Staff**

(1) Reported that:—

(*a*) Dr D. L. Gunn, Director, assumed duties on 1-10-59.
(*b*) Dr M. T. Hutchinson, Specialist in Nematology, assumed duties on 20-8-59.
(*c*) Mr C. B. Foster-Barham, Chief Advisory Officer, assumed duties on 16-11-59.
(*d*) The following new appointments were made to the staff:—
  (1) Mr U. L. M. de Silva, Technical Assistant to Low-Country Adviser.
  (2) Mr P. V. Arulpragasam, Assistant to Pathologist.
  (3) Mr N. S. Rajendram, Assistant to Physiologist.
  (4) Mr K. P. G. S. W. Karunaratne, Research Assistant to Agricultural Chemist.
  (5) Mr A. H. R. Balthazaar, Assistant to Agricultural Chemist.
  (6) Mr A. R. M. Hassim, Assistant to Physiologist.
  (7) Mr D. J. M. Hettiarachi, Photographer.
  (8) Mr K. M. L. B. Fernando, Assistant Electrician.

(2) **Request for carpets, etc.** (Vide Item 3 (2) of Administrative Committee minutes of 16-10-59).

Mr Coultas said the then Director, the Chief Administrative Officer and himself had visited the bungalows at St Coombs, and the recommendations of the Administrative Committee were based on the report arising from this inspection.

After some discussion Mr R. J. Gilmour moved, seconded by Mr B. Mahadeva, that the recommendations of the Administrative Committee be accepted. The motion was carried by eight votes to five.

(3) **Mr E. N. Perera — Provident Fund Benefits** (Vide Item 8 (6) of Administrative Committee minutes of 16-10-59.

The Director made some proposals for the enhancement of Provident Fund benefits.

After some discussion Mr Gilmour proposed, seconded by Mr Mahadeva, that Mr E. N. Perera be granted six months' full-pay leave preparatory to retirement on the grounds of ill-health. The Board approved.

It was agreed that the Director's proposals regarding Provident Fund benefits be referred to the Administrative Committee for proper study and report.

(4) **Acknowledgments**

Reported that:—

Mr E. L. Keegel had conveyed his thanks to the Board for extending medical facilities to all children of the senior staff under 21 years of age, and Mr J. A. H. Tolhurst had conveyed his appreciation for extending the passage allowance for overseas staff to include a third child.

13. **Other Business**

(1) **Pembroke Bungalow**

Reported that the Department of Agriculture had now decided not to acquire this bungalow, but was willing to pay a rental for the bungalow as determined by the Chief Valuer.

Agreed that the bungalow be rented to the Department of Agriculture at a rental to be determined by the Chief Valuer, which should also include the insurance premia being paid. The rental was to be charged retrospectively from the date of occupation in March, 1959.

It was also agreed that the bungalow be advertised for sale, the Department of Agriculture to be informed of these decisions.

(2) **Shot-hole Borer**

Mr Macintyre said that at one of the P.A. meetings it was mentioned that Shot-hole Borer was number one enemy of the tea industry and the biggest problem for the Institute and he asked whether any information was available on this matter.

Dr Gunn said that insecticide spraying trials were going on and looking promising, but the Institute would not yet make any recommendations. Some planters were also carrying out experiments and the Institute was collecting information.

Next Meeting

The next meeting of the Board was fixed for Friday, 4th March, 1960, at St Coombs.

Sgd. H. J. BALMOND,
Secretary,
Board of Control.

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